

Quantum Physics and the Identity of Indiscernibles

There has been much discussion in the literature ([1], [2], [3], [4], [5], [6]) as to whether atomic particles of the same species \mathcal{P} , which share the same intrinsic state-independent properties of mass, spin, electric charge etc. violate the Leibnizian Principle of the Identity of Indiscernibles (PII). The sense that, while there is more than one of them, their state-dependent properties may also all be the same. The answer depends on what exactly the state-dependent properties are taken to be. Other authors have concentrated on the question of whether the state-dependent properties can be identified with the eigenvalues of the quantum-mechanical state. This runs into the difficulty that in general indistinguishable particles, tested in joint measurements, are in entangled states that do not permit ascribing maximally specific pure states to each particle. The best that can be done is to describe the indistinguishable particles by improper mixtures.

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[The present work follows a different line of attack. The state-dependent properties are plausibly identified with all the monadic and relational properties that can be ascribed in terms of physical magnitudes expressed with self-adjoint operators that can be defined for the individual particles.

IP says that permitted observables must satisfy $\langle \phi | Q | \phi \rangle = \langle \phi | P^{-1} Q P | \phi \rangle$ for all states $|\phi\rangle$ and all particle permutations P

Now for a two-particle system, defining $Q_1 = Q \otimes I$ and $Q_2 = I \otimes Q$, where Q is a one-particle observable, and are concerned with properties expressed by marginal probabilities of the form $\text{Prob}^{|\Psi\rangle}(Q_1 = q^1)$ and $\text{Prob}^{|\Psi\rangle}(Q_2 = q^2)$ where $|\Psi\rangle$ is the quantum-mechanical state of the joint system and q^i is some eigenvalue of the self-adjoint operator Q_i and are with relational properties expressed by conditional probabilities of the form $\text{Prob}^{|\Psi\rangle}(Q_1 = q^1 | Q_2 = q^2)$ and $\text{Prob}^{|\Psi\rangle}(Q_2 = q^2 | Q_1 = q^1)$.

new para [It must be recognized that Q_1 and Q_2 are not themselves observables on the two-particle system, where limitations on permitted 'observables' due to the Indistinguishability Postulate (IP) introduced in [7] are taken into account. **extension* Nevertheless it is argued that from an ontological point of view there are the appropriate quantities to investigate in discussion of PII.

new para [The analysis is extended to two-particle distributions in order to ~~show~~ ^{most} examples of the case of parapermutables where states support hyper-order ^{irreducible} representations of the Symmetric Group.

representation
new para [It is concluded that the weakest form of PII involving all relevant modes

ord relativistic properties is violated
for boson, fermions and higher-order
particles, tested in few experiments.

[1] Barnette Cortes, A.

[2] Barnette, R. L.

[3] Ginzburg, A.

[4] Teller, P.

[5] Shodmi, Y.

[6] Van Freeman, B.

[7] Greenberg O. V. and ^{MESSIAH} Pomark, A. M. L.